



A Comparison of the Capabilities of Four Command and Control Systems at the Platoon Level and Below

by Bruce S. Sterling and Cheryl A. Burns

ARL-TN-0217

June 2004

NOTICES

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of manufacturer's or trade names does not constitute an official endorsement or approval of the use thereof.

DESTRUCTION NOTICE—Destroy this report when it is no longer needed. Do not return it to the originator.

Army Research Laboratory

Aberdeen Proving Ground, MD 21005-5425

ARL-TN-0217**June 2004**

A Comparison of the Capabilities of Four Command and Control Systems at the Platoon Level and Below

Bruce S. Sterling and Cheryl A. Burns
Human Research & Engineering Directorate, ARL

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.				
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.				
1. REPORT DATE (DD-MM-YYYY) June 2004		2. REPORT TYPE Final		3. DATES COVERED (From - To)
4. TITLE AND SUBTITLE A Comparison of the Capabilities of Four Command and Control Systems at the Platoon Level and Below		5a. CONTRACT NUMBER		
		5b. GRANT NUMBER		
		5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S) Bruce S. Sterling and Cheryl A. Burns (both of ARL)		5d. PROJECT NUMBER 62716AH70		
		5e. TASK NUMBER		
		5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Research Laboratory Human Research & Engineering Directorate Aberdeen Proving Ground, MD 21005-5425		8. PERFORMING ORGANIZATION REPORT NUMBER ARL-TN-0217		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)		
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.				
13. SUPPLEMENTARY NOTES				
14. ABSTRACT <p>This report examines the capabilities of four command and control (C2) systems, as perceived by users of these systems at platoon level and below. All four systems were used in a virtual and constructive simulation run at the unit of action maneuver battle lab (UAMBL). Each system was assessed on ability to perform certain critical functions (e.g., view the common operational picture, understand the situation, war game plans, control fires); fulfill critical information requirements (CIRs), based on mission-enemy-terrain-own troops-time available-civilians; situational awareness; and workload. The Defense Advanced Research Projects Agency (DARPA) future C2 (FC2) system, judged by far the best on critical functions and CIR, had the best rated situational awareness (SA) and lowest rated workload. The system seen as next best was the surrogate communication, command, control, and computer (SC4) interface. However, it was rated far below the DARPA FC2 system on critical functions and CIR, with most critical functions and CIR rated as poor, but still having relatively few ratings of very poor. The reported SA was slightly below and workload was somewhat above the DARPA system. The maneuver C2 (MC2) and force XXI battle command brigade and below (FBCB2) systems were both assessed even lower on critical functions and CIR, with participants often reporting that certain functions and CIRs were "not applicable" to those systems. The SA for those systems was somewhat lower than SC4, with workloads comparable to SC4. The FBCB2 had the highest number of ratings in the very poor range.</p> <p>These findings are similar to an independent assessment by UAMBL. Participants rated the DARPA FC2 as effective in displaying information, the SC4 as relatively neutral, and the MC2 and FBCB2 as ineffective to very ineffective. Also, participants rated the ability to perform battle command as easy in the DARPA FC2, neutral in the SC4, and difficult to very difficult in the MC2 and FBCB2.</p> <p>Perceived differences among the systems are assessed in terms of differences in participants' level of training and experience with the systems; differences in the common operating pictures, differences in battle damage assessment and attack guidance matrix, or calls for fire. Conclusions concern test conditions necessary to conduct a valid user assessment of future systems.</p>				
15. SUBJECT TERMS future leadership; future platoon leaders; future skills required; job assessment				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UL	18. NUMBER OF PAGES 30
a. REPORT UNCLASSIFIED	b. ABSTRACT UNCLASSIFIED	c. THIS PAGE UNCLASSIFIED		
			19a. NAME OF RESPONSIBLE PERSON Bruce S. Sterling	
			19b. TELEPHONE NUMBER (Include area code) 502-624-1964	

Contents

List of Tables	v
1. Introduction	1
1.1 Overview	1
1.2 Battle Command Experiment	1
2. Method	6
2.1 Participants	6
2.2 Instruments	6
2.3 Procedure	6
2.4 Analyses	6
3. Results	7
3.1 DARPA FC2 System	7
3.1.1 DARPA FC2 Functionalities	7
3.1.2 DARPA FC2 CIRs	7
3.1.3 DARPA FC2 SA and Workload	9
3.2 SC4 System	10
3.2.1 SC4 Functionalities	10
3.2.2 SC4 CIRs	11
3.2.3 SC4 SA and Workload	12
3.3 MC2 System	12
3.3.1 MC2 Functionalities	12
3.3.2 MC2 CIRs	13
3.3.3 MC2 SA and Workload	14
3.4 FBCB2 System	14
3.4.1 FBCB2 Functionalities	15
3.4.2 FBCB2 CIRs	15
3.4.3 FBCB2 SA and Workload	16
4. Discussion	17
4.1 DARPA FC2 Summary	17

4.2	SC4 Summary	17
4.3	MC2 Summary	17
4.4	FBCB2 Summary	17
4.5	Overall Summary	18
5.	Bibliography	20
	Appendix A. ARL Survey	21
	Acronyms	24
	Distribution List	26

List of Tables

Table 1. Experts' assessment of the four systems.....	3
Table 2. DARPA FC2 functionalities.	8
Table 3. DARPA FC2 CIRs rated good to very good overall.	9
Table 4. DARPA FC2 CIRs rated borderline overall.	9
Table 5. DARPA FC2 SA and workload.	10
Table 6. SC4 functionalities rated borderline.	10
Table 7. SC4 functionalities rated poor.	11
Table 8. SC4 CIRs.	11
Table 9. SC4 SA and workload.....	12
Table 10. MC2 functionalities.	13
Table 11. MC2 CIRs.....	14
Table 12. MC2 SA and workload.	14
Table 13. FBCB2 functionalities.	15
Table 14. FBCB2 CIRs.....	16
Table 15. FBCB2 SA and workload.	16

INTENTIONALLY LEFT BLANK

1. Introduction

1.1 Overview

This research concerns the capabilities of four command and control systems at platoon level and below, as perceived by users in a combined virtual and constructive simulation. We begin with a review of the experiment in which this research was embedded. This review draws heavily on the unit of action maneuver battle lab (UAMBL) battle command (BC) report. We then discuss the method of data collection used in this research. We follow by presenting results by command, control, communication, computer (C4) system and position. Finally, we discuss the implications of the findings for the four systems.

1.2 Battle Command Experiment

The primary purpose of this study was to review and examine selected surrogate BC systems to evaluate system functionality and Soldier-machine interface attributes as a foundation for the evolving user's functional description work. The secondary purpose of this study was to provide a recommendation for an interim surrogate BC system to be used in Army modeling and simulation work through fiscal year 2004 (FY04). This surrogate will be used only until the lead system integrator (LSI) surrogate BC system is fully developed, fielded, and can be integrated into the Army's core model OneSAF (one semi-automated forces) test bed (OTB). This is expected to be complete by third quarter 2004.

BC systems that were reviewed and examined follow:

<u>BC system</u>	<u>Study dates</u>
DARPA FC2	14 Jul – 18 Jul 03
SC4	28 Jul – 01 Aug 03
MC2	11 Aug – 13 Aug 03
FBCB2	18 Aug – 22 Aug 03

The Defense Advanced Research Projects Agency (DARPA) future command and control (FC2) has strong planning, rehearsal, and collaboration capabilities, similar to the maneuver command and control (MC2) system. Enemy battle tracking, battle damage assessment, and tools to track friendly strength are similar to the MC2. File-sharing ability and interface design are moderately good.

The simulated C4 (SC4) has the ability to plan collaboratively but cannot do automated war gaming. Its strength, however, is in battle tracking, with the ability to track enemy entities and tailor the screen to one's preferences. It has cumbersome file storage and sharing capabilities. It

has the ability to conduct networked fires and do battle damage assessment (BDA). Its interface is the least common to Windows¹, and it appears to be most difficult to master.

The MC2 is an outgrowth of the maneuver control system, a tool used by operations officers in current units at battalion and brigade levels. Its strengths are in planning, rehearsal and collaboration. It has file-sharing and word-processing capability. It has the ability for networked fires. It can automatically revise enemy activity. It has some ability to track friendly combat strength. The interface is more common with Windows, compared to Force XXI battle command brigade and below (FBCB2).

The FBCB2 is the Army's current primary BC system at brigade and below. Perhaps its strength is "knowing where you are and your buddies are" through its connection with the unit's position location system. It has no planning or rehearsal capabilities and no ability for networked fires. Enemy activity is only reported and revised manually. It has good file storing and e-mail capabilities.

Differences in these systems and how they were implemented in the experiment are given in table 1. This chart is based on discussions with battle lab personnel concerning the four C4 systems. These differences and their implications are discussed in the summary.

Each BC system was brought to Fort Knox, Kentucky, one week before the study dates listed to conduct technical integration. Training was conducted during the integration week and during the first few days of the evaluation period.

The scope of this study was to review and examine surrogate C2 systems at the mounted combat system (MCS) crew and platoon level. Ensuing FY04 experiments and studies will augment this study and will review and examine system functionality and Soldier-machine interface at the platoon and company level, company and battalion level, and battalion and brigade level.

This study used a derivative of the U.S. Army Training and Doctrine Command-approved scenario previously used by UAMBL during the FY03 May concept experimentation plan (CEP), CASPIAN 2.0. This scenario focused on the UA offensive actions in varied terrain. To best capture objective force concepts, three terrain configurations of open and rolling, complex, and urban were used.

¹WindowsTM is a trademark of Microsoft.

Table 1. Experts' assessment of the four systems.

Attribute	DARPA FC2	SC4	MC2	FBCB2
Training	<ul style="list-style-type: none"> - Operated and evaluated by DARPA well-trained subject matter experts (SMEs) - Own crew structure – a combat vehicle (CV) crew 	<ul style="list-style-type: none"> - Most players reasonably familiar with interface (still could not send overlays) 	<ul style="list-style-type: none"> - Lack of training (does more if players could have used it); example is good planning capability in MC2 but not adequately trained 	<ul style="list-style-type: none"> - Lack of training on system
BDA	<ul style="list-style-type: none"> - Good, BDA – “chaser” that followed round and sent picture to be evaluated to revise common operational picture (COP) 	<ul style="list-style-type: none"> - Level 4 detection (identification) by sensor automatically updated 	<ul style="list-style-type: none"> - No automated method for revising BDA – Manual based on line of sight (see burning) only 	<ul style="list-style-type: none"> - No method for revising BDA at all – never done
Attack guidance matrix (ATGM) and fires	<ul style="list-style-type: none"> - Had ATGM – same as MC2 	<ul style="list-style-type: none"> - Had ATGM - Could call for fire 	<ul style="list-style-type: none"> - Had ATGM but could not override it – training issue - Gunner could not fire off of MC2 - Could not fire cooperative engagements 	<ul style="list-style-type: none"> - No ATGM or call for fire; used SC4 for firing –sent e-mail - Had to maintain graphics on all systems to know where to fire
Planning	<ul style="list-style-type: none"> - Good collaboration and planning - same as MC2 	<ul style="list-style-type: none"> - Strength is execution, can plan and share overlays via whiteboard, but no war-gaming capabilities (auto-mated playback of plan) 	<ul style="list-style-type: none"> - Good collaboration and planning capabilities (not trained) but at platoon level not as important 	<ul style="list-style-type: none"> - No collaboration across echelons – with SC4 - No route planning
COP	<ul style="list-style-type: none"> - Simple COP: One combined arms company that did not match the force structure used on other systems (other interfaces depicted entire battalion) - Each operator had two screens on which he could display different views, plus a common screen in the center of the vehicle (called “heads up” display) - Map scalable; lose resolution when zoomed in – same as MC2 and FBCB2; 1 to 50k; Better quality terrain display - Picture icons versus mil std - Not standard BLUEFOR; had mixture of MCS, infantry carrier vehicles - Programmed threat, little control possible, fired automatically - Filters 	<ul style="list-style-type: none"> - Complex COP One platoon with command headquarters, but entire battalion depicted - One screen per operator - Map scalable not actual map - Standard BLUEFOR; 1 MCS Company - Standard opposing forces (OPFOR) – CO + - Filters – not trained 	<ul style="list-style-type: none"> - Complex COP; same as SC4 - One screen per operator - Current map only a picture; cannot scale too close; front line trace difficult – 1 to 100k - Standard BLUEFOR; 1 MCS Company - Standard OPFOR - Filters, logistics avail-able but not adequately trained 	<ul style="list-style-type: none"> - Complex COP; same as SC4 - Tool bars not customizable - Information under icons not relevant - One screen per operator - Map scalable - Terrain did not match OTB; vegetation not displayed 1 to 50k - Standard BLUEFOR; 1 MCS Company - Standard OPFOR - Filters – not trained
Delay	<ul style="list-style-type: none"> - Ran on own version of OTB, so no delay times 	<ul style="list-style-type: none"> - Interfaced with OTB but still delays 	<ul style="list-style-type: none"> - Severe problems with screen delays due to interface problems with OTB (bad router) - Could not navigate because of delay times (drivers turned off MC2) 	<ul style="list-style-type: none"> - Some problems with screen delays due to interface with OTB (COP update poor)
Windows	<ul style="list-style-type: none"> - Windows-based product 	<ul style="list-style-type: none"> - Not a Windows-based product 	<ul style="list-style-type: none"> - Windows-based product 	<ul style="list-style-type: none"> - Not a Windows-based product
Terrain	<ul style="list-style-type: none"> - Different terrain (National Training Center [NTC] database) 	<ul style="list-style-type: none"> - Standard terrain Caspian 2 	<ul style="list-style-type: none"> - Standard terrain Caspian 2 	<ul style="list-style-type: none"> - Standard terrain Caspian 2
Crew	<ul style="list-style-type: none"> - Own crew structure – a CV crew 	<ul style="list-style-type: none"> - MCS crew structure (vehicle commander, driver, crew chief) 	<ul style="list-style-type: none"> - MCS crew structure (vehicle commander, driver, crew chief) 	<ul style="list-style-type: none"> - MCS crew structure (vehicle commander, driver, crew chief)

The following limitations and constraints were imposed on this study:

1. The ability to develop scenarios to fully access all four BC systems was limited. This constraint was most significant with the DARPA FC2 system. This system was reviewed and examined with an operational test bed version that was completely different from the version used to examine the three other systems. Additionally, the terrain data were the NTC, and friendly and enemy force structure was different from the other systems.
2. Training time available to train players and all other participants was significantly limited. Crew and platoon players and study participants were kept consistent to minimize training requirements. For the SC4, MC2, and FBCB2, a single commander portrayed the platoon leader for all three BC systems reviewed and examined. Other crew and platoon players were consistent to the maximum extent possible. For the DARPA system, a single person represented each position (commander, battlespace manager, information operations, and effects officer). Blue, red, and white cell (WC) players were the same for all four systems reviewed and examined. We used surrogate C2 system SMEs provided by the surrogate C2 system proponent agency to play selected players' positions. This methodology was most evident with the DARPA FC2 system with three of the four crew members played by DARPA SMEs.
3. The study was limited to two vignettes with two runs each. All systems, except for the DARPA FC2, were reviewed and examined with two modified vignettes from the UAMBL May 03 CEP. The first vignette took place in open and rolling terrain, and the second vignette used more complex terrain culminating with urban operations. Two runs per vignette were scheduled, starting with operations in open and rolling terrain conducted on Thursday and operations in complex terrain conducted on Friday. Because of integration problems, the evaluation of MC2 was limited to a total of two runs.
4. The study size was limited by the use of only two MCS crews as a part of an MCS platoon for three of the systems, as described before. Only one command vehicle crew was used for the DARPA system. For the other three systems, the platoon leader's and platoon sergeant's vehicles were played virtually with three crew positions manned in each vehicle. The third vehicle in the MCS platoon and two remaining MCS platoons in the MCS company were played constructively.
5. Roles of crew members for the DARPA and other systems were different. For the DARPA system, the commander functioned as a company-level commander; the battlespace manager functioned more or less as an operations non-commissioned officer (NCO); the information operations manager functioned as an intelligence NCO, and the effects officer coordinated direct and indirect fires. For the other three systems, the crew chief served as vehicle commander, directing the actions of the driver and gunner, as well as receiving orders and requests for information from higher echelons, providing information to adjacent or higher echelons, viewing the COP on the C2 interface, and calling for fires.

The driver maneuvered the vehicle, under direction of the crew chief, and the gunner was responsible for responding to close-in threats.

6. Various surrogate C2 system and devices reviewed and examined for this study reflect the latest technology and capabilities available but did not provide the complete functionality expected in the FC2 system.
7. Although all participants were trained in UA and future combat systems concepts, their understanding was limited and they had limited time to internalize proposed concepts and coalesce as a cohesive, highly efficient team.
8. Most, if not all, of the operational and organizational concepts for exploration are still undergoing development. As a result, tactics, techniques, and procedures; crew functions; information management protocols; and other concepts changed over time as concepts matured and the players became more experienced.
9. Certain capabilities, although considered fundamental to the C4 intelligence, surveillance, and reconnaissance (C4ISR) capability of the various commanders, were not replicated or investigated in this experiment. These include but are not limited to network security mechanisms and procedures, automated network management, tamper warning systems, and information dissemination protocols.
10. Environment and threat: This study was conducted with the current version of the OTB, a human-in-the-loop, simulation-supported, secure environment. Appropriate slice(s) from various elements in the UA were represented in the study with nodes staffed with personnel to constructively simulate the tactical simulation environment appropriate for an MCS platoon. A WC was established to perform this function. A red cell controlled by WC red forces (REDFOR) was used to create a feasible tactical environment for the MCS platoon leader within the construction of the OPFOR plan and the limits of the OPFOR capabilities. The friendly forces and control of the OPFOR were different for the DARPA system. The friendly forces for the DARPA system consisted of a company "+" containing both MCS and ICVs, while the friendly force for the other systems was an MCS company. The OPFOR was more highly scripted for the DARPA system, whereas the other systems were controlled by REDFOR. Analytical effort focused on players and crews and how they interfaced with the BC system and the processes used to execute battle command.

2. Method

2.1 Participants

For the DARPA FC2 interface, we collected data for four personnel (commander, battlespace manager, information operations, and effects) after each of the two scenarios. For the other three interfaces, we collected data for two personnel in each of the three positions (crew chief, driver, and gunner) on two runs for each of the two scenarios. Thus, each participant completed the survey as many as four times during the experiment. Therefore, we had as many as eight surveys completed per position.

2.2 Instruments

The same survey was used for all four interfaces. The survey assessed functionalities, critical information provided concerning mission, enemy, time, own troops, terrain, civilians (METT-TC), situational awareness (SA), and workload. There were 16 questions concerning how well¹ the interface performed certain functionalities (e.g., develop operations order [OPORD] and graphics). There were 21 questions on the same scale concerning how well the interface provided critical METT-TC information (e.g., information about location of enemy units). There was one 10-point scale (“could not perform task” to “able to perform task well all the time”) for SA. There were four 10-point scales (“workload low” to “task abandoned-unable to supply sufficient effort”) for workload. These questions covered workload to maintain SA, plan the mission, maneuver forces and control fires.

2.3 Procedure

The surveys were completed after the end of mission. For the DARPA FC2 interface, it was given once after each of the two scenarios. For the other interfaces, it was administered after each of the two runs for each of the two scenarios (four times per participant).

2.4 Analyses

Because of the small number of participants at each level and repeated administrations, only descriptive statistics (means) were reported. We analyzed data by position and interface.

¹On a five-point scale where 1 = “very poor”; 2 = “poor”; 3 = “borderline”; 4 = “good”; and 5 = “very good”.

3. Results

3.1 DARPA FC2 System

Tables 2 through 4 contain the mean ratings (averaged over both iterations) for each position, and over all positions, for each question on the ARL questionnaire. The tables represent functionalities, critical information requirements (CIRs), and SA and workload. Tables are color coded so that items with means of more than 4 (“good” to “very good”) are colored green; items with means of 3 to less than 4 (“borderline”) are colored yellow; and items with means of less than 3 (“poor” to “very poor”) are colored red. The number for responses was two per position. Overall, ratings were quite high.

3.1.1 DARPA FC2 Functionalities

Overall, all functionalities were rated as good. The commander’s mean ratings reached or exceeded 4.0 (“good”) except for filter information and respond to changes in a timely manner. The latter item is critical for commanders, however, in that exploiting the situation is a key aspect of the future doctrine. The battlespace manager’s ratings were at least 4.0 on all items. The information operations officer’s ratings met or exceeded 4.0 on all items except comprehension and projection. These items are also critical, particularly for the information operations officer. The effects officer had the most items with mean ratings less than 4.0. These items included filter information, develop plan, and control fires. The latter item is a critical one for the effects officer’s job. There were no functionalities with overall mean ratings less than 4.0.

3.1.2 DARPA FC2 CIRs

Table 2 contains all CIR rated good to very good overall. Nearly all CIRs were rated as good overall. Commanders and battlespace managers were most positive, with information operations officers and effects officers as less positive, suggesting that the interface did not meet their needs quite as much. For CIRs, the commander’s ratings averaged less than 4.0 on only one item, effects of terrain on friendly maneuver. The battlespace manager’s ratings met or exceeded 4.0 on all items. The information operations officer’s ratings were below 4.0 on numerous items, including effects of terrain on enemy maneuver and effects of time on enemy maneuver, friendly maneuver, and logistics. The effects officer’s ratings of CIR also were less than 4.0 on numerous items. These included enemy strength or size, location of obstacles, location, strength or size, and activity of own troops, and effects of time on enemy maneuver and logistics.

Table 2. DARPA FC2 functionalities.

Question	CDR	Battlespace MGR	Info Ops	Effects	Overall
a. View the joint COP (everyone having access to the same information, across services and coalition, in real time)	4.0	5.0	Missing	4.5	4.5
b. Filter information (adapt the view to your needs; e.g., see only one type of element only)	3.5	5.0	4.5	3.5	4.1
c. Understand where you are in the menu system	4.0	Missing	4.5	4.0	4.2
d. <i>Perception</i> of relevant information (e.g., can you <i>see</i> the icons/information that you need)	5.0	5.0	4.0	4.0	4.5
e. <i>Comprehension</i> of the situation (e.g., does the program help you <i>understand</i> what you see on the screen)	4.0	5.0	3.5	4.0	4.1
f. <i>Projection</i> of what will happen in the near future (e.g., does the program help you to <i>predict and plan for</i> what will happen in the future)	4.5	4.5	3.5	4.0	4.1
g. Access relevant information online (e.g., battle book describing enemy system capabilities)	4.5	Missing	Missing	4.0	4.3
h. Develop plans collaboratively (e.g., work <i>together</i> with war fighters in other locations)	5.0	5.0	5.0	3.5	4.6
i. War game plans collaboratively (e.g., work <i>together</i> to analyze different courses of action)	4.5	5.0	5.0	4.5	4.8
j. Develop OPORDs and create graphics	4.5	5.0	5.0	4.0	4.6
k. Distribute OPORDs and graphics	5.0	5.0	5.0	4.5	4.9
l. Rehearse the plan	5.0	5.0	5.0	5.0	5.0
m. Maneuver forces	4.0	5.0	4.5	4.0	4.4
n. Control fires	4.0	5.0	4.0	3.5	4.1
o. Notice changes in the situation in a timely manner	4.5	5.0	4.5	4.0	4.5
p. Respond to changes in the situation in a timely manner	3.0	5.0	4.0	4.0	4.0
Scale: 1 = very poor; 2 = poor; 3 = borderline; 4 = good; 5 = very good					
Color coding: Green = good; yellow = borderline; red = poor					

Table 3 contains CIRs rated as borderline overall. These items include enemy activity, friendly and enemy BDA, and location of civilians on the battlefield. Friendly and enemy BDA were a concern, especially to the information operations officer and effects officer. This makes sense, considering that tracking friendly and enemy strength would be key tasks of the information operations officer, and tracking the enemy BDA would be critical to the effects officer. The commander's ratings were borderline only for information concerning BDA on own troops. The battlespace manager rated all items as good. The information operations officer rated information about BDA for own troops as borderline and information about enemy BDA as poor. Effects officers rated information about all four items as borderline.

Table 3. DARPA FC2 CIRs rated good to very good overall.

Question	CDR	Battlespace MGR	Info Ops	Effects	Overall
a. Mission – Scheme of maneuver and graphics	4.5	5.0	4.0	4.0	4.4
b. Mission – Commander’s intent	4.5	4.5	5.0	4.0	4.5
c. Enemy – Type of unit	4.5	4.5	4.5	4.0	4.4
d. Enemy – Location of units	4.9	4.5	4.0	4.0	4.2
e. Enemy – Strength or size of units	4.5	4.5	4.5	3.0	4.2
h. Terrain – Location of obstacles	4.0	5.0	Missing	3.5	4.0
i. Terrain – Effects on enemy maneuver (e.g., terrain analysis tools)	4.5	5.0	3.0	4.0	4.3
j. Terrain – Effects on friendly maneuver	3.5	5.0	4.0	4.0	4.1
k. Own Troops – Type of unit	4.0	5.0	5.0	4.0	4.5
l. Own Troops – Location of units	4.5	5.0	5.0	3.5	4.5
m. Own Troops – Strength or size of units	5.0	5.0	5.0	3.5	4.6
n. Own Troops – Activity (pattern recognition tools)	4.5	4.5	4.5	3.5	4.3
p. Time – Effects on enemy maneuver	4.5	5.0	3.0	3.5	4.0
q. Time – Effects on friendly maneuver	4.0	5.0	3.5	4.0	4.1
r. Time – Effects on logistics (e.g., rate of consumption)	5.0	5.0	3.5	3.5	4.1
t. Civilians on the battlefield – Strength or size	5.0	Missing	4.0	4.0	4.2
u. Civilians on the battlefield – Activity (pattern recognition tools)	4.0	Missing	4.0	4.0	4.0
Scale: 1 = very poor; 2 = poor; 3 = borderline; 4 = good; 5 = very good					
Color coding: Green = good; yellow = borderline; red = poor					

Table 4. DARPA FC2 CIRs rated borderline overall.

Question	CDR	Battlespace MGR	Info Ops	Effects	Overall
f. Enemy – Activity (pattern recognition tools)	4.0	4.0	4.0	3.5	3.9
o. Own Troops – Battle damage assessment	3.5	4.5	3.5	3.5	3.8
g. Enemy – Battle damage assessment	4.5	4.0	2.0	3.5	3.5
s. Civilians on the battlefield – Location	4.0	Missing	4.0	3.5	3.8
Scale: 1 = very poor; 2 = poor; 3 = borderline; 4 = good; 5 = very good					
Color coding: Green = good; yellow = borderline; red = poor					

3.1.3 DARPA FC2 SA and Workload

Overall, SA was seen as reasonably good and workload rather light. This makes sense, given the generally positive ratings of the functions and CIR. Overall ratings of SA (7.1) corresponded to “Not complete – able to perform task, but not satisfactorily.” The ratings did not vary much over duty position.

Workload ratings are reversed from the scale in appendix A for consistency with other ratings in this report. That is, higher numbers reflect lower workload (good) and lower numbers reflect higher workload (bad). Workload ratings were heaviest for maintain SA, corresponding to “reduced spare capacity.” The effects officer apparently had the easiest time maintaining SA. Workload for other tasks was relatively light, corresponding roughly to “enough spare capacity.” The information operations officer seemed to have the lightest workload for planning, controlling maneuver, and controlling fires.

Table 5. DARPA FC2 SA and workload.

Question	Commander	Battlespace Manager	Information Operations	Effects	Overall
SA	7.0	8.0	6.5	7.0	7.1
Workload – Maintain SA	4.5	4.5	4.0	7.0	5.0
Workload – Plan	8.0	8.0	8.5	7.5	8.0
Workload – Maneuver	6.0	4.0	8.0	6.5	6.2
Workload – Control fires	5.0	6.0	8.0	6.5	6.4

3.2 SC4 System

Tables 6 through 9 contain the mean ratings (averaged over all iterations) for each position, and over all positions, for each question on the ARL questionnaire. The tables represent functionalities, CIRs, and SA and workload. The number of responses was eight per position, with the exception of missing values (participants who did not answer a particular question). Overall, ratings were low.

3.2.1 SC4 Functionalities

Overall, SC4 functionalities were rated as poor. For SC4 functionalities, overall ratings for only two items even reached 3.0 (“borderline”). They are displayed in table 6. These items were understanding where you were in the menu system and comprehension of the situation (Level II SA). Ratings by the crew chief were just slightly lower than ratings by the other two positions on these two items. While comprehension of the situation is critical, the system fails to provide much other functionality needed for C2.

Table 7 contains functionalities rated as poor. All three positions gave roughly equivalent ratings on these items. The driver tended to have slightly higher ratings on most items and gave perception (Level I SA), controlling maneuver forces and controlling fires borderline ratings. All three factors are important to the driver’s job (see where you are, move, and position platform to shoot). Ominously, the crew chief, who subjectively appeared to use the interface the most, gave the lowest ratings on most items.

Table 6. SC4 functionalities rated borderline.

Question	Crew Chief	Gunner MGR	Driver	Overall
c. Understand where you are in the menu system	2.9	3.0	3.3	3.0
e. <i>Comprehension</i> of the situation (e.g., does the program help you <i>understand</i> what you see on the screen)	2.9	3.1	2.9	3.0
Scale: 1 = very poor; 2 = poor; 3 = borderline; 4 = good; 5 = very good Color coding: Green = good; yellow = borderline; red = poor				

Table 7. SC4 functionalities rated poor.

Question	Crew Chief	Gunner MGR	Driver	Overall
a. View the joint COP (everyone having access to the same information, across services and coalition, in real time)	2.5	3.0	2.6	2.7
b. Filter information (adapt the view to your needs; e.g., see only one type of element only)	2.4	2.7	2.7	2.6
d. <i>Perception</i> of relevant information (e.g., can you <i>see</i> the icons/information that you need)	2.6	2.8	3.2	2.8
f. <i>Projection</i> of what will happen in the near future (e.g., does the program help you to <i>predict and plan for</i> what will happen in the future)	1.8	2.1	2.5	2.1
g. Access relevant information online (e.g., battle book describing enemy system capabilities)	2.0	2.0	2.5	2.2
h. Develop plans collaboratively (e.g., work <i>together</i> with war fighters in other locations)	2.1	2.7	2.7	2.5
i. War game plans collaboratively (e.g., work <i>together</i> to analyze different courses of action)	2.0	2.4	2.8	2.4
j. Develop OPORDs and create graphics	2.8	2.5	2.7	2.7
k. Distribute OPORDs and graphics	2.4	2.8	2.7	2.7
l. Rehearse the plan	2.6	2.4	2.7	2.6
m. Maneuver forces	2.5	2.7	3.0	2.7
n. Control fires	2.6	2.6	3.0	2.7
o. Notice changes in the situation in a timely manner	2.4	2.6	2.7	2.5
p. Respond to changes in the situation in a timely manner	2.4	2.6	2.9	2.6
Scale: 1 = very poor; 2 = poor; 3 = borderline; 4 = good; 5 = very good Color coding: Green = good; yellow = borderline; red = poor				

3.2.2 SC4 CIRs

Ability of the interface to supply CIR was seen uniformly as poor. No ratings reached 3.0, and one (effects of time on logistics) was even less than 2.0 (“poor”). For CIR, the crew chief tended to have the higher ratings, although only understanding of mission (commander’s intent) even reached borderline. The gunner tended to have the lowest ratings, with none reaching borderline. Of the driver’s ratings, understanding the scheme of maneuver (arguably his most important task) reached borderline.

Table 8. SC4 CIRs.

Question	Crew Chief	Gunner	Driver	Overall
a. Mission – Scheme of maneuver and graphics	2.8	2.5	3.2	2.8
b. Mission – Commander’s intent	3.0	2.2	2.3	2.6
c. Enemy – Type of unit	2.7	2.2	2.1	2.4
d. Enemy – Location of units	2.9	2.0	2.7	2.5
e. Enemy – Strength or size of units	2.9	2.1	2.3	2.5
f. Enemy – Activity (pattern recognition tools)	2.8	1.2	2.2	2.2
g. Enemy – Battle damage assessment	2.7	2.0	1.8	2.3
h. Terrain – Location of obstacles	2.3	1.5	2.2	2.1
i. Terrain – Effects on enemy maneuver (e.g., terrain analysis tools)	2.7	1.3	2.0	2.1
j. Terrain – Effects on friendly maneuver	2.6	2.3	2.4	2.4
k. Own troops – Type of unit	2.6	2.8	2.9	2.8
l. Own troops – Location of units	2.8	2.6	2.7	2.7

m. Own troops – Strength or size of units	2.3	2.3	2.3	2.3
n. Own troops – Activity (pattern recognition tools)	2.4	2.4	2.8	2.5
o. Own troops – Battle damage assessment	2.3	1.6	2.8	2.3
p. Time – Effects on enemy maneuver	2.5	2.0	2.3	2.3
q. Time – Effects on friendly maneuver	2.5	2.2	2.0	2.3
r. Time – Effects on logistics (e.g., rate of consumption)	1.9	1.7	2.0	1.9
s. Civilians on the battlefield – Location	2.8	1.8	2.3	2.3
t. Civilians on the battlefield – Strength or size	2.1	2.0	1.8	2.0
u. Civilians on the battlefield – Activity (pattern recognition tools)	2.5	1.8	1.8	2.1
Scale: 1 = very poor; 2 = poor; 3 = borderline; 4 = good; 5 = very good				
Color coding: Green = good; yellow = borderline; red = poor				

3.2.3 SC4 SA and Workload

Overall, SA was fair, and workload surprisingly light. SA was rated “insufficient” to “not complete” for all positions. Surprisingly, this was not much worse than the DARPA interface, which received much higher ratings on functionalities and CIR. Workload overall was not excessive, around 5.0 to 6.0 (insufficient spare capacity to reduced spare capacity).

Table 9. SC4 SA and workload.

Question	Crew Chief	Gunner	Driver	Overall
SA	6.3	6.1	7.3	6.5
Workload – Maintain SA	4.5	5.4	7.1	5.7
Workload – Plan	4.4	4.2	5.5	4.7
Workload – Maneuver	3.9	5.7	5.1	4.9
Workload – Control fires	4.4	5.9	4.7	5.0

3.3 MC2 System

Tables 10 through 12 contain the mean ratings (averaged over all iterations) for each position, and over all positions, for each question on the ARL questionnaire. The tables represent functionalities, CIRs, and SA and workload. The number of responses was eight per position, with the exception of missing values (participants who did not answer a particular question). Overall, ratings were quite low. Also, there was substantially more missing data (e.g., not applicable or blank ratings) than for other systems.

3.3.1 MC2 Functionalities

MC2 functionalities were rated uniformly poor. For functionalities, no ratings reached 3.0 (“borderline”). A few, such as accessing information on line and controlling fires, did not even average 2.0, falling in the “very poor” range. Many of the driver’s ratings were borderline, although for key features such as maneuver forces, ratings were poor. The driver also had a few areas where ratings were missing, which suggested that they were not used or considered missing from the interface. The crew chief and gunner each only had a few areas where the functionalities just reached borderline. For the crew chief, the key feature of maneuver forces did reach borderline.

Table 10. MC2 functionalities.

Question	Crew Chief	Gunner	Driver	Overall
a. View the joint COP (everyone having access to the same information, across services and coalition, in real time)	2.3	1.0	3.0	2.3
b. Filter information (adapt the view to your needs; e.g., see only one type of element only)	2.5	3.0	3.5	2.9
c. Understand where you are in the menu system	2.8	2.0	1.7	2.2
d. <i>Perception</i> of relevant information (e.g., can you <i>see</i> the icons/information that you need)	2.5	2.0	2.0	2.3
e. <i>Comprehension</i> of the situation (e.g., does the program help you <i>understand</i> what you see on the screen)	2.5	2.0	2.3	2.4
f. <i>Projection</i> of what will happen in the near future (e.g., does the program help you to <i>predict and plan for</i> what will happen in the future)	2.5	3.0	Missing	2.6
g. Access relevant information online (e.g., battle book describing enemy system capabilities)	1.0	1.0	Missing	1.0
h. Develop plans collaboratively (e.g., work <i>together</i> with war fighters in other locations)	2.5	1.5	3.0	2.4
i. War game plans collaboratively (e.g., work <i>together</i> to analyze different courses of action)	2.3	2.5	3.0	2.6
j. Develop OPORDs and create graphics	2.3	2.3	3.0	2.4
k. Distribute OPORDs and graphics	2.8	2.3	3.0	2.6
l. Rehearse the plan	3.0	2.3	4.0	2.8
m. Maneuver forces	3.3	1.0	2.0	2.3
n. Control fires	2.0	1.0	Missing	1.8
o. Notice changes in the situation in a timely manner	1.8	1.0	1.0	1.4
p. Respond to changes in the situation in a timely manner	2.3	1.0	3.0	2.2
Scale: 1 = very poor; 2 = poor; 3 = borderline; 4 = good; 5 = very good				
Color coding: Green = good; yellow = borderline; red = poor				

3.3.2 MC2 CIRs

The ability of the MC2 to fulfill CIR was uniformly seen as poor. This time, there were numerous ratings below 2.0 (“poor”), along with many missing data. The CIRs rated below “poor” included location, strength and activity of enemy units; location of obstacles; activity and BDA of own troops; all aspects of time (effects on enemy maneuver, friendly maneuver and logistics); and size or strength of civilians on the battlefield. Drivers’ ratings mostly were either borderline or missing, suggesting that the MC2 basically met drivers’ needs of the interface. Exceptions were information about the enemy (location, activity, and BDA). Gunners had a few borderline ratings for type of enemy unit and effects of terrain on friendly and enemy maneuver. Crew chiefs rated all aspects of CIR as poor to very poor.

Table 11. MC2 CIRs.

Question	Crew Chief	Gunner	Driver	Overall
a. Mission – Scheme of maneuver and graphics	2.3	1.8	3.0	2.3
b. Mission – Commander’s intent	2.3	2.0	3.0	2.3
c. Enemy – Type of unit	2.3	3.0	Missing	2.5
d. Enemy – Location of units	1.7	1.5	2.5	1.9
e. Enemy – Strength or size of units	1.5	1.0	3.0	1.8
f. Enemy – Activity (pattern recognition tools)	1.5	Missing	1.0	1.3
g. Enemy – Battle damage assessment	2.5	Missing	1.0	2.0
h. Terrain – Location of obstacles	1.0	2.0	Missing	1.5
i. Terrain – Effects on enemy maneuver (e.g., terrain analysis tools)	1.5	3.0	Missing	2.0
j. Terrain – Effects on friendly maneuver	2.0	3.0	4.0	2.6
k. Own Troops – Type of unit	2.5	2.3	3.5	2.7
l. Own Troops – Location of units	2.5	2.0	3.0	2.5
m. Own Troops – Strength or size of units	2.3	1.0	3.5	2.4
n. Own Troops – Activity (pattern recognition tools)	2.0	1.0	Missing	1.8
o. Own Troops – battle damage assessment	1.5	1.0	Missing	1.3
p. Time – Effects on enemy maneuver	2.0	1.0	Missing	1.8
q. Time – Effects on friendly maneuver	1.8	1.0	Missing	1.6
r. Time – Effects on logistics (e.g., rate of consumption)	2.0	1.0	Missing	1.5
s. Civilians on the battlefield – Location	2.0	Missing	Missing	2.0
t. Civilians on the battlefield – Strength or size	1.0	Missing	Missing	1.0
u. Civilians on the battlefield – Activity (pattern recognition tools)	2.0	Missing	Missing	2.0
Scale: 1 = very poor; 2 = poor; 3 = borderline; 4 = good; 5 = very good				
Color coding: Green = good; yellow = borderline; red = poor				

3.3.3 MC2 SA and Workload

SA was low, as would be expected. Workload, however, was also light. SA was relatively low, around 4.0 (very low to low), as may be expected from the other ratings. Somewhat surprisingly, based on their ratings, crew chiefs had the highest SA. Workload was also relatively light, from just above 6.0 for planning (“insufficient spare capacity”) to around 5.0 for SA, maneuver, and fires (reduced spare capacity).

Table 12. MC2 SA and workload.

Question	Crew Chief	Gunner	Driver	Overall
SA	5.5	4.0	2.3	4.1
Workload – Maintain SA	5.7	5.0	4.0	5.3
Workload – Plan	7.2	5.5	-	6.3
Workload – Maneuver	6.7	5.0	4.0	5.4
Workload – Control fires	5.0	5.0	-	5.0

3.4 FBCB2 System

Tables 13 and 14 contain the mean ratings (averaged over all iterations) for each position and over all positions, for each question on the ARL questionnaire. The tables represent functionalities, CIRs, and SA and workload. The number of responses was eight per position, with the exception of missing values (participants who did not answer a particular question).

Overall, ratings were quite low. Also, there was substantial missing data (e.g., not applicable or blank ratings) than for other systems.

3.4.1 FBCB2 Functionalities

Functionalities were seen as uniformly poor. For functionalities, no overall rating reached 3.0 (borderline). Seven overall ratings did not even reach 2.0 (poor). These were ratings for filter information, understanding where you were in the menu system, projection of what will happen in the future, war gaming and rehearsing plans, controlling fires, and enabling rapid responses to changes. Drivers had the highest ratings but also the most missing ratings, implying that the functionality did not apply to drivers or did not exist. Drivers had two poor ratings, one of which was maneuver forces, which seems to be the driver's main task. Crew chiefs and gunners rated functionalities as uniformly poor. Generally, gunners had the lowest responses.

Table 13. FBCB2 functionalities.

Question	Crew Chief	Gunner MGR	Driver	Overall
a. View the joint COP (everyone having access to the same information, across services and coalition, in real time)	2.5	1.5	3.0	2.4
b. Filter information (adapt the view to your needs; e.g., see only one type of element only)	1.5	1.3	Missing	1.4
c. Understand where you are in the menu system	2.3	1.3	1.5	1.8
d. <i>Perception</i> of relevant information (e.g., can you <i>see</i> the icons/information that you need)	2.5	1.0	3.0	2.1
e. <i>Comprehension</i> of the situation (e.g., does the program help you <i>understand</i> what you see on the screen)	2.5	1.3	3.0	2.1
f. <i>Projection</i> of what will happen in the near future (e.g., does the program help you to <i>predict and plan for</i> what will happen in the future)	2.0	1.0	Missing	1.8
g. Access relevant information online (e.g., battle book describing enemy system capabilities)	2.0	2.0	Missing	2.0
h. Develop plans collaboratively (e.g., work <i>together</i> with war fighters in other locations)	2.0	2.5	Missing	2.2
i. War game plans collaboratively (e.g., work <i>together</i> to analyze different courses of action)	2.0	1.5	Missing	1.8
j. Develop OPORDs and create graphics	3.0	2.3	3.0	2.7
k. Distribute OPORDs and graphics	3.0	1.5	3.0	2.4
l. Rehearse the plan	1.5	2.0	Missing	1.8
m. Maneuver forces	2.3	1.7	2.5	2.1
n. Control fires	2.0	1.3	Missing	1.7
o. Notice changes in the situation in a timely manner	2.3	1.0	Missing	2.0
p. Respond to changes in the situation in a timely manner	2.3	1.0	Missing	1.8
Scale: 1 = very poor; 2 = poor; 3 = borderline; 4 = good; 5 = very good Color coding: Green = good; yellow = borderline; red = poor				

3.4.2 FBCB2 CIRs

The interface's ability to provide CIR was rated as uniformly poor. For CIRs, ratings were quite low, with a high percentage of missing (not applicable) responses. Again, no overall response

reached 3.0 (borderline). There were eight items to which overall responses did not reach 2.0 (poor). These were information about enemy strength and enemy activity; all terrain-related items (location of obstacles, effects on enemy and friendly maneuver); and strength, activity, and BDA for own troops. Drivers rated critical information needs seemingly relevant to them as borderline. These included scheme of maneuver, friendly and enemy type and location of units. Crew chiefs and gunners rated the interface's ability to provide CIR as uniformly poor. Again, gunners' ratings were mostly the lowest.

Table 14. FBCB2 CIRs.

Question	Crew Chief	Gunner	Driver	Overall
a. Mission – Scheme of maneuver and graphics	2.5	1.7	3.0	2.3
b. Mission – Commander's intent	2.0	2.0	Missing	2.0
c. Enemy – Type of unit	2.7	2.0	3.0	2.5
d. Enemy – Location of units	2.5	1.7	3.0	2.3
e. Enemy – Strength or size of units	1.7	1.0	Missing	1.5
f. Enemy – Activity (pattern recognition tools)	1.7	1.0	Missing	1.4
g. Enemy – Battle damage assessment	3.0	1.5	Missing	2.0
h. Terrain – Location of obstacles	2.0	1.3	Missing	1.5
i. Terrain – Effects on enemy maneuver (e.g., terrain analysis tools)	2.0	1.7	Missing	1.8
j. Terrain – Effects on friendly maneuver	2.0	1.5	Missing	1.8
Question	Crew Chief	Gunner	Driver	Overall
k. Own Troops – Type of unit	2.0	2.0	3.0	2.2
l. Own Troops – Location of units	2.3	1.7	3.0	2.2
m. Own Troops – Strength or size of units	1.7	1.5	Missing	1.6
n. Own Troops – Activity (pattern recognition tools)	1.3	1.5	Missing	1.4
o. Own Troops – Battle damage assessment	2.5	1.0	Missing	1.8
p. Time – Effects on enemy maneuver	2.0	Missing	Missing	2.0
q. Time – Effects on friendly maneuver	2.0	Missing	Missing	2.0
r. Time – Effects on logistics (e.g., rate of consumption)	2.0	Missing	Missing	2.0
s. Civilians on the battlefield – Location	Missing	2.0	Missing	2.0
t. Civilians on the battlefield – Strength or size	Missing	2.0	Missing	2.0
u. Civilians on the battlefield – Activity (pattern recognition tools)	Missing	2.0	Missing	2.0
Scale: 1 = very poor; 2 = poor; 3 = borderline; 4 = good; 5 = very good				
Color coding: Green = good; yellow = borderline; red = poor				

3.4.3 FBCB2 SA and Workload

SA was relatively low but still higher than the MC2. Workload was about the same as the MC2. The SA ratings were around 5.0 (reduced). Driver's SA was the highest. However, workload was not excessive, also around 5.0 (reduced spare capacity). Drivers did not report workload except for maneuver.

Table 15. FBCB2 SA and workload.

Question	Crew Chief	Gunner	Driver	Overall
SA	4.8	4.7	7.0	5.2
Workload – Maintain SA	5.5	5.0	-	5.3
Workload – Plan	6.0	5.0	-	5.6
Workload – Maneuver	5.2	5.7	5.0	5.3
Workload – Control fires	5.5	5.0	-	5.3

4. Discussion

4.1 DARPA FC2 Summary

Functionality of the system was seen as good. However, it is somewhat disconcerting that individuals seemed to rate the system relatively low concerning key aspects of their jobs. For instance, the commander rated the system low (compared to other ratings) in enabling him to respond to changes in a timely manner. The information operations officer rated the system low in providing comprehension and projection, and the effects officer rated the system low in controlling fires.

Ability of the system to meet CIR was also good, although more aspects were seen as borderline. Ratings of BDA were the lowest, with two of four positions giving ratings less than good to enemy BDA and three of four positions giving ratings less than good to friendly BDA. Other CIRs for which two of the four positions (information operations and effects) gave ratings of less than good were effects of time on enemy maneuver and logistics. However, the other two positions (commander and battlespace manager) gave these CIR high ratings.

Overall, SA was rated good and workload light. The heaviest workload was for maintaining SA and the lightest for planning, suggesting that the interface may be better for planning than for maintaining SA.

4.2 SC4 Summary

Overall ratings of system functions and CIRs were quite low. There were no large discrepancies among the three positions. However, the SA was adequate and workload was not excessive.

4.3 MC2 Summary

Overall, ratings of system functions and CIRs were quite low. Many data were coded as “not applicable” or “missing,” indicating that participants did not perceive the system as having these functions or address these CIRs. Overall, SA was low and workload was light. Drivers tended to be more positive but also rated more functions or CIRs as “not applicable”

4.4 FBCB2 Summary

Overall, ratings were quite low, with numerous instances of falling short of even poor overall. Also, there were many instances of missing data, where respondents did not think that functionalities or CIRs applied to the system. The SA was relatively low, but workload was light for the most part. Again, drivers tended to be somewhat more positive but also rated more functions or CIRs as “not applicable.”

4.5 Overall Summary

The DARPA FC2 system had by far the best functionality and ability to fulfill CIR, best rated SA, and lowest rated workload. The next highest system was the SC4. However, it was seen as far less adequate in functionality and ability to fulfill CIR than the DARPA FC2 but still had relatively few assessments below “poor.” The reported SA was slightly below and workload was somewhat above the DARPA system. The MC2 and FBCB2 systems were both seen as less adequate in functionality and ability to fulfill CIR than even the SC4, with participants often reporting that certain functions and CIRs were “not applicable” to those systems. The SA for those systems was somewhat lower than SC4, with workloads comparable to SC4. The FBCB2 had the highest number of assessments below “poor.”

These findings are somewhat similar to an independent assessment by UAMBL. Participants rated the DARPA FC2 as effective in displaying information, the SC4 as relatively neutral, and the MC2 and FBCB2 as ineffective to very ineffective. Also, participants rated the ability to perform battle command as easy in the DARPA FC2, neutral in the SC4, and difficult to very difficult in the MC2 and FBCB2.

The DARPA system seems to have been rated the highest based on four factors: training experience, COP, BDA, and ATGM (fires). The DARPA system was operated by highly trained, experienced personnel who could take advantage of all the features that the system possessed. It had a simple COP since only one friendly company was depicted and since the system used its own version of OTB, there were no interface problems with battle lab OTB. Thus, the COP always accurately represented the simulation. The system postulated that each round fired was followed by a “chaser” round that provided an assessment of BDA, so BDA was virtually automatically revised. The system provided for network calls for fire (ATGM), and users were well trained to employ the ATGM.

The SC4 seems to be the second most highly rated system based on these four factors. Participants for the other systems were drawn from the battle lab, which has used SC4 in their experiments for years, so they were reasonably experienced with use of SC4. The COP was moderately accurate, since some delays were experienced in interfacing with OTB but were not nearly as bad as those for MC2. The enemy BDA was not amended with every round, as with the DARPA system, but if a sensor made a level 4 detection (identification) of a platform, it accurately reported BDA. The system had an ATGM (call for fire) which operators knew how to use.

The MC2 seems to be the third most highly rated system based on the four factors. Participants had relatively little experience or training on this complex system. The COP was very poor because of severe interface problems with the OTB. The COP was sometimes delayed half an hour from what was occurring in the simulation, making it un-usable. The only way BDA could be assessed and revised was by line of sight. That is, if a player saw an enemy system in flames through his vision blocks, he could then manually revise the BDA. This was far less satisfactory

than the other two systems. Finally, although the system had an ATGM, a lack of training interfered with its use. Participants could not override the ATGM even to engage an enemy vehicle within direct fire range.

The FBCB2 seems to be the worst system based on these four factors. The level of training and experience on the system (low) was similar to the MC2. The COP was about as timely as with the SC4, but there were mismatches in the terrain in the simulation and on the FBCB2, so the FBCB2 could not be used for terrain analysis or determining routes. There was no mechanism in the system for calling for fires (fires were called in via SC4). Participants lacked the ability to revise BDA, even if they could visually assess damage to enemy vehicles. The low ratings seem to be reasonable, based on problems with terrain, a lack of ability to call for fires, or record their effects.

These findings point to some critical factors necessary for one to be able to accurately assess system functionality. Participants need to be (equally) highly trained and experienced in the systems used, so they can avail themselves of all the functionality the system provides. The interface with the simulation being run must be (equally) good, providing real-time information about what is occurring in the simulation, and the force structure available to be displayed on the COP must be the same for all systems. Otherwise, problems with the connection between OTB and the C4 system will confound assessment of the C4 system. In addition, all systems should have some way of assessing and amending BDA from the simulation. Perhaps the technique used for the SC4 is the most realistic. That is, if a sensor is in a position to identify an entity, BDA is automatically revised. This does not necessarily assume automatic target recognition, a technology that may not be available for some time. That is, the assumption is that whoever is operating the sensor gets some sort of video feed and manually revises the COP on that basis. From the user's perspective, it appears to be "automatic," but that would still be true if there actually were a Soldier in the loop working with the sensor. Finally, all systems should have some way of inserting calls for fire into the simulation. This is a requirement in the operational requirements document, so any future C4 system must have this capacity. It is just a matter of ensuring that this capacity is properly represented (i.e., connected to the OTB).

5. Bibliography

Defense Advanced Research Project Agency (2002). *DARPA Future Combat System Unit Cell C2 Architecture Study Interim Report*. Washington, D.C.: Defense Advanced Research Project Agency.

Department of the Army (2002). *FBCB2 User Functional Description – FY 00*, Fort Monroe, VA.: U.S. Army Training and Doctrine Command.

Department of the Army (2003). *The US Army Objective Force Operational and Organizational Plan Maneuver Unit of Action*, TRADOC Pam 525-3-90. Fort Monroe, VA.: U.S. Army Training and Doctrine Command.

U.S. Army Armor School and Center (2003). *UAMBL Battle Command Study*. Fort Knox KY: Unit of Action Maneuver Battle Lab.

U.S. Army Armor School and Center (2003). *UAMBL, Operational Requirements Document for the Future Combat Systems Change 3* (JROC Approved). Fort Knox KY: Unit of Action Maneuver Battle Lab.

ARL (HRED) Battle Command Study Survey

1. Position/Station ___ Commander ___ Battlespace Manager
 ___ Information and Operations ___ Effects
2. Interface used ("x" one) ___ DARPA FCS C2 ___ MC2 ___ LSI ___ FCB2 ___ SC4
3. Run ("x" one) ___ Day 1 Run 1 ___ Day 1 Run 2 ___ Day 2 Run 1 ___ Day 2 Run 2
4. Functionalities: How well does the interface (computer hardware & software) give you abilities to do the following?

21

6. Rate the interface on the following scale concerning the following information. How well does the interface (computer hardware and software) provide you with the information that you must have concerning:

(place an X in the appropriate box)	Very Poor	Poor	Borderline	Good	Very Good
a. Mission – Scheme of maneuver and graphics					
b. Mission – Commander's intent					
c. Enemy – Type of unit					
d. Enemy – Location of units					
e. Enemy – Strength or size of units					
f. Enemy – Activity (pattern recognition tools)					
g. Enemy – Battle Damage Assessment					
h. Terrain – Location of obstacles					
i. Terrain - Effects on enemy maneuver (e.g., terrain analysis tools)					
j. Terrain - Effects on friendly maneuver					
k. Own Troops – Type of unit					
l. Own Troops – Location of units					
m. Own Troops – Strength or size of units					
n. Own Troops – Activity (pattern recognition tools)					
o. Own Troops – Battle Damage Assessment					
p. Time – Effects on enemy maneuver					
q. Time – Effects on friendly maneuver					
r. Time - Effects on logistics (e.g., rate of consumption)					
s. Civilians on the battlefield – Location					
t. Civilians on the battlefield – Strength or size					
u. Civilians on the battlefield – Activity (pattern recognition tools)					

6. Situational Awareness (SA): Rate your Situational Awareness (SA) during the vignette on the following scale:

Far Too Low - Could not perform the task because I did not possess the necessary information	Extremely Low - Unaware of almost all the information required to perform the task	Very Low - Unaware of most of the information required to perform the task	Low - Unaware of about half the information required to perform the task	Reduced - Unaware of some important information required to perform the task	Insufficient - Not aware of all the information required to perform the task	Not Complete - Able to perform the task, but not satisfactorily	Mostly Good - Able to perform the task well most of the time	Good - Able to perform task well all the time	Excellent Able to perform task extremely well all the time

7. Workload: Rate your workload for the following tasks during the vignette on the following scale

Tasks:	Workload Insignificant	Workload Low	Enough spare capacity for all desirable additional tasks	Insufficient spare capacity for easy attention to additional tasks	Reduced spare capacity – additional tasks cannot be given the desired amount of attention	Little spare capacity – level of effort allows little attention to additional tasks	Very little spare capacity – but maintenance of effort in the primary task not in question	Very high workload with almost no spare capacity – difficulty in maintaining level of effort	Extremely high workload – no spare capacity and difficulty in maintaining level of effort	Task abandoned – unable to apply sufficient effort
Maintain SA										
Plan mission										
Maneuver forces										
Control fires										

8. Shared SA: Concerning the current vignette that you have just completed, please briefly answer the three questions listed in the column headings below for the leadership position you occupied yourself (if listed) and the other position indicated.

- #1: What was the most important task for the occupant of this position?
 #2: What resources (information or action) did the occupant of this position need to accomplish the above task?
 #3: What was the biggest problem (identified or potential) that the occupant of this position currently faced?

	#1 Most Important Task	#2 Resources Needed	#3 Biggest Problem
Commander			
Information and Operations			
Battlespace Manager			
Effects			

Acronyms

ARL	Army Research Laboratory
ATGM	attack guidance matrix
BC	battle command
BDA	battle damage assessment
CEP	concept experimentation plan
CIR	critical information requirement
COP	common operational picture
C2	command and control
C4ISR	command, control, communication, computers, intelligence, surveillance, reconnaissance
CV	combat vehicle
DARPA	Defense Advanced Research Projects Agency
FBCB2	Force XXI battle command brigade and below
FC2	Future command and control
HRED	Human Research and Engineering Directorate
ICV	infantry carrier vehicle
LSI	lead system integrator
MCS	mounted combat system
MC2	maneuver command and control
METT-TC	mission, enemy, time, own troops, terrain, civilians
NCO	non-commissioned officer
NTC	National Training Center
OneSAF	one semi-automated forces
OPFOR	opposing forces
OPORD	operations order
OTB	OneSAF test bed
REDFOR	red forces
SA	situational awareness
SC4	simulated command, control, communications, computer
SME	subject matter expert
UAMBL	unit of action maneuver battle lab
WC	white cell

NO. OF
COPIES ORGANIZATION

* ADMINISTRATOR
DEFENSE TECHNICAL INFO CTR
ATTN DTIC OCA
8725 JOHN J KINGMAN RD STE 0944
FT BELVOIR VA 22060-6218
*pdf file only

1 DIRECTOR
US ARMY RSCH LABORATORY
ATTN AMSRD ARL CI IS R REC MGMT
2800 POWDER MILL RD
ADELPHI MD 20783-1197

1 DIRECTOR
US ARMY RSCH LABORATORY
ATTN AMSRD ARL CI OK TECH LIB
2800 POWDER MILL RD
ADELPHI MD 20783-1197

1 DIRECTOR
UNIT OF ACTION MANEUVER BATTLE LAB
ATTN ATZK UA
BLDG 1101
FORT KNOX KY 40121

1 ARL HRED AVNC FLD ELMT
ATTN AMSRD ARL HR MJ D DURBIN
BLDG 4506 (DCD) RM 107
FT RUCKER AL 36362-5000

1 ARL HRED AMCOM FLD ELMT
ATTN AMSRD ARL HR MI
BLDG 5464 RM 202
REDSTONE ARSENAL AL
35898-5000

1 ARL HRED AMCOM FLD ELMT
ATTN AMSRD ARL HR MO T COOK
BLDG 5400 RM C242
REDSTONE ARS AL 35898-7290

1 ARL HRED USAADASCH FLD ELMT
ATTN AMSRD ARL HR ME
K REYNOLDS
ATTN ATSA CD
5800 CARTER ROAD
FORT BLISS TX 79916-3802

1 ARL HRED ARDEC FLD ELMT
ATTN AMSRD ARL HR MG R SPINE
BUILDING 333
PICATINNY ARSENAL NJ
07806-5000

NO. OF
COPIES ORGANIZATION

1 ARL HRED ARMC FLD ELMT
ATTN AMSRD ARL HR MH C BURNS
BLDG 1002 ROOM 117
1ST CAVALRY REGIMENT RD
FT KNOX KY 40121

1 ARL HRED CECOM FLD ELMT
ATTN AMSRD ARL HR ML J MARTIN
MYER CENTER RM 2D311
FT MONMOUTH NJ 07703-5630

1 ARL HRED FT BELVOIR FLD ELMT
ATTN AMSRD ARL HR MK P SCHOOL
10170 BEACH RD
FORT BELVOIR VA 22060-5800

1 ARL HRED FT HOOD FLD ELMT
ATTN AMSRD ARL HR MV HQ USAOTC
S MIDDLEBROOKS
91012 STATION AVE ROOM 111
FT HOOD TX 76544-5073

1 ARL HRED FT HUACHUCA
FIELD ELEMENT
ATTN AMSRD ARL HR MY M BARNES
RILEY BARRACKS BLDG 51005
FT HUACHUCA AZ 85613

1 ARL HRED FLW FLD ELMT
ATTN AMSRD ARL HR MZ A DAVISON
320 MANSCEN LOOP STE 166
FT LEONARD WOOD MO 65473-8929

1 ARL HRED NATICK FLD ELMT
ATTN AMSRD ARL HR MQ M R FLETCHER
NATICK SOLDIER CTR BLDG 3
RM 341 AMSSB RSS E
NATICK MA 01760-5020

1 ARL HRED OPTEC FLD ELMT
ATTN AMSRD ARL HR MR H DENNY
ATEC CSTE PM ARL
4501 FORD AVE RM 870
ALEXANDRIA VA 22302-1458

1 ARL HRED SC&FG FLD ELMT
ATTN AMSRD ARL HR MS R ANDERS
SIGNAL TOWERS RM 303A
FORT GORDON GA 30905-5233

1 ARL HRED STRICOM FLD ELMT
ATTN AMSRD ARL HR MT A GALBAVY
12350 RESEARCH PARKWAY
ORLANDO FL 32826-3276

NO. OF
COPIES ORGANIZATION

- 1 ARL HRED TACOM FLD ELMT
ATTN AMSRD ARL HR MU M SINGAPORE
6501 E 11 MILE RD MAIL STOP 284
BLDG 200A 2ND FL RM 2104
WARREN MI 48397-5000

- 1 ARL HRED USAFAS FLD ELMT
ATTN AMSRD ARL HR MF L PIERCE
BLDG 3040 RM 220
FORT SILL OK 73503-5600

- 1 ARL HRED USAIC FLD ELMT
ATTN AMSRD ARL HR MW E REDDEN
BLDG 4 ROOM 332
FT BENNING GA 31905-5400

- 1 ARL HRED USASOC FLD ELMT
ATTN AMSRD ARL HR MN R SPENCER
DCSFDI HF
HQ USASOC BLDG E2929
FORT BRAGG NC 28310-5000

- 1 ARL HRED HFID FLD ELMT
ATTN AMSRD ARL HR MP
D UNGVARSKY
BATTLE CMD BATTLE LAB
415 SHERMAN AVE UNIT 3
FT LEAVENWORTH KS 66027-2326

- 1 CDR AMC - FAST
JRTC & FORT POLK
ATTN AFZX GT DR J AINSWORTH
CMD SCIENCE ADVISOR G3
FORT POLK LA 71459-5355

- 1 CDR HRED AMEDD
ATTN AMSRD ARL HR MM N VAUSE
2250 STANLEY RD STE 322
FT SAM HOUSTON TX 78234

ABERDEEN PROVING GROUND

- 1 DIRECTOR
US ARMY RSCH LABORATORY
ATTN AMSRD ARL CI OK TP (TECH LIB)
BLDG 4600

- 1 DIRECTOR
US ARMY RSCH LABORATORY
ATTN AMSRD ARL CI OK TP S FOPPIANO
BLDG 459

NO. OF
COPIES ORGANIZATION

- 1 DIRECTOR
US ARMY RSCH LABORATORY
ATTN AMSRD ARL HR MB
F PARAGALLO
BLDG 459

- 1 DIRECTOR
US ARMY RSCH LABORATORY
ECBC FLD ELMT
ATTN AMSRD ARL HR M
BLDG 459